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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 46.

B. T. GALLOWAY, *Chief of Bureau.*

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BUREAU OF PLANT INDUSTRY

THE PROPAGATION OF TROPICAL FRUIT TREES AND OTHER PLANTS.

BY

GEORGE W. OLIVER, EXPERT.

SEED AND PLANT INTRODUCTION AND DISTRIBUTION.

ISSUED AUGUST 8, 1903

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1903.

BULLETINS OF THE BUREAU OF PLANT INDUSTRY.

The Bureau of Plant Industry, which was organized July 1, 1901, includes Vegetable Pathological and Physiological Investigations, Botanical Investigations and Experiments, Grass and Forage Plant Investigations, Pomological Investigations, and Experimental Gardens and Grounds, all of which were formerly separate Divisions, and also Seed and Plant Introduction and Distribution, the Arlington Experimental Farm, Tea Culture Investigations, and Domestic Sugar Investigations.

Beginning with the date of organization of the Bureau, the several series of Bulletins of the various Divisions were discontinued, and all are now published as one series of the Bureau. A list of the Bulletins issued in the present series follows.

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[Continued on p. 3 of cover.]

FIG. 1.—METHOD OF INARCHING MANGO IN INDIA, USING TWO STOCKS.

FIG. 2.—SADDLE METHOD OF INARCHING MANGO, USED IN INDIA.

FIG. 3.—MANGO PLANTS FROM INDIA, SHOWING CONDITION ON ARRIVAL IN THE UNITED STATES.

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BEVERLY T. GALLOWAY, *Chief of Bureau.*

SEED AND PLANT INTRODUCTION AND DISTRIBUTION.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., June 4, 1903.

Sir: I have the honor to transmit herewith, and to recommend for publication as Bulletin No. 46 of the series of this Bureau, the accompanying paper entitled "The Propagation of Tropical Fruit Trees and Other Plants."

This paper was prepared by Mr. George W. Oliver, an Expert of this Bureau, and has been submitted by the Botanist in Charge of Seed and Plant Introduction and Distribution with a view to publication.

The eight half-tone plates accompanying this paper are considered necessary to a complete understanding of the text.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE PROPAGATION OF TROPICAL FRUIT TREES AND OTHER PLANTS.

INTRODUCTION.

The purpose of this bulletin is to furnish short notes dealing with the most feasible methods of propagating such tropical and subtropical fruit trees and other economic plants as have thus far received little or no attention in the United States and its near-by tropical possessions.

Considerable progress has already been made in introducing new and improved varieties of the fruits mentioned here, and experiments are being carried on with a view to simplifying the old methods of increasing the supply of these plants.

The seeds of many varieties of trees and other plants have been sown to produce fruiting specimens, notably the mango and the loquat. The result of this method of propagation has almost invariably been only a partial success with most of the subjects and wholly unsatisfactory with others.

Where seeds of any desirable fruit trees are available, they should, of course, be sown and the seedlings planted out in permanent locations when large enough; but these seedlings should only be used as stocks on which to bud or graft varieties of known value. In few cases can seedlings be depended upon for the production of fruit; the product is almost certain to be of inferior quality. Even if the parent tree be of a superior variety, seedlings are likely to revert to the original species. Therefore, as the seedlings of tropical fruits are as a rule of healthy and vigorous growth, their best use will be to supply a good foundation on which to work scions from good trees.

Other economic plants, such as tea and Manila hemp, have also been found to yield better products when propagated vegetatively than when grown from seeds. The hemp plant belongs to a division of the vegetable kingdom the members of which do not readily lend themselves to either budding or grafting, but it can be propagated quickly by other means of vegetative reproduction. The tea plant may also be multiplied vegetatively without resorting to budding or grafting.

As the propagation of most of the trees and plants dealt with in

this paper can be accomplished by the use of but few of the methods of budding and grafting, only those methods which it is necessary to employ will be described in detail.

THE MANGO.

PROSPECTS AS A FRUIT TREE.

The Department of Agriculture is constantly in receipt of letters from present or prospective growers of the mango in the subtropical regions of the United States and its tropical possessions, asking for instructions as to the best method of propagating the finer varieties of the mango. Like most other fruit trees, it has been found that even when the seeds of good varieties are planted the fruit of the resulting seedlings is almost invariably inferior to that of the parent.

The mango will undoubtedly grow in popular favor. At present, unfortunately, it is suffering from a bad reputation, owing to the fact that the fruits which have been placed before the public in recent years have been grown mainly from seedling trees that are only fit to be used as stocks or wind-breaks. They are in fact wild or jungle mangoes and bear the same relation to the improved forms that the crab apple does to the Baldwin or Ben Davis apple. The prejudice which exists against them will, it is believed, disappear when the finer varieties become known. This will not be in a year or two, because there are comparatively few plants in the country which are worthy of growing, and so far as the writer is aware the fruit of only one of them has found its way North.

A short cut to success in raising a large number of trees of any approved variety is found in budding, or transferring a single bud, with a good-sized piece of bark attached, from a good variety to the stem or branch of a healthy stock plant raised from seed. In this way, from the growth made by the bud, exactly the same fruit is obtained as that produced by the tree from which the bud was taken. The stock on which the bud is inserted may be dwarf or tall; it may be vigorous or otherwise, and to the extent that these peculiarities occur in the stock it will, in a large measure, transmit similar peculiarities to the growth of the scion. But if the fruit of the stock should be of a fibrous nature and of an undesirable flavor, these characteristics exercise no influence whatever upon the fruit of the scion. Therefore nothing is gained by propagation from seed beyond perhaps the raising of new forms arising from artificially pollinated flowers or otherwise.

There is every probability that the finer varieties of Asiatic origin will soon be grown in the South much more extensively than heretofore. Not only has the Department of Agriculture had its agents on the lookout for improved varieties in India and elsewhere, resulting

in several consignments to the Department greenhouses of many kinds reputed to be of great value, but a few private growers have also been importing some varieties which are highly praised. The acquisition by the United States of tropical possessions will render the cultivation of the mango of greater importance than ever. The fruit can not be imported from the Philippines, but it will be an easy matter to import young plants of the best of the many varieties growing there. In Porto Rico the tree thrives very luxuriantly and the fruit grown there can be landed in New York within five days; but there is a large tract of land in southern Florida where the mango thrives to perfection, and when once the growers become acquainted with the best methods of propagation, so that only the finest kinds shall be grown, the establishment of a large and profitable industry may be expected, for it is reasonably certain that the demand for mangoes of good variety will always keep pace with the supply.

PROPAGATION IN INDIA.

In India, the home of mango growing, propagation is effected by very crude methods, grafting by approach being the principal one. The union is made in several ways. Sometimes two stocks are planted close enough together so that a union may be secured on both with a single branch of a desirable variety. The method is shown in Plate I. figs. 1 and 3. Another method, shown in Plate I, fig. 2, consists in preparing the stock as in saddle grafting; an incision is then made in the thick part of a branch of the variety to be propagated, and this is fitted over the wedge-shaped top of the stock. The percentage of successful unions by these devices is said to be sometimes quite high compared with more rational methods, but the unions are never as satisfactory as could be desired. The young trees have to be supported by tying them to stout sticks, as there is danger of their being snapped off at the union by windstorms.

Grafting by approach or inarching has hitherto been the principal method of grafting in Florida and elsewhere in America, but for the reasons indicated above very little progress has been made in increasing the supply of first-class varieties.

PROPAGATING TESTS AT THE DEPARTMENT.

Numerous budding and grafting tests have been conducted in the greenhouses of the Department of Agriculture, beginning in the latter part of 1901 and continuing through the following summer. The trials were not as extensive as could be wished, owing to lack of good material. In spite of this drawback the results were not without value, and it is doubtful whether they would have been different had the trials been on a much larger scale. The experiments were

inaugurated to determine the best wood for budding and grafting, because it is evident that one of the principal reasons for so many failures in the propagation of the mango is the use of the wrong kind of wood, especially for budding.

BEST AGE FOR WOOD.

It has been found that very indifferent results are obtained from wood which is less than a year old, but very satisfactory unions have been secured by the use of bud wood from branches from one to six years old. This is not to be wondered at, at least from the propagator's point of view, when we consider that the wood of the mango takes a longer time to mature than that of most of the fruit and forest trees of this country. The mango makes several distinct growths or "flushes" each summer; it will make a shoot with a number of leaves, then rest for a few weeks, when the terminal bud of the shoot will again start into growth. This is repeated in many instances as often as seven times before the close of the growing season. By midsummer, the wood of the first growth looks to the uninitiated as if it were much older than it really is, and this same wood is that which is commonly selected to give material for budding.

THICK BARK OF MANGO AN OBSTACLE IN BUDDING.

In connection with these experiments it was observed also that part of the difficulty experienced in budding the mango may be ascribed to the thickness of the bark, which does not allow a good union to be made by the usual methods employed in budding thin-barked trees. In shield-budding the mango, where the bark is raised on each side of the longitudinal cut in the stock and the bud inserted, there is too much air space left, resulting in almost every case in the death of the bud through the shrinking of the bark when not sufficiently supplied with moisture from the stock. The bark to which the bud is attached will shrivel to one-half its original bulk in a day or two. Decay will then almost certainly set in. In budding it is imperative that as close a fit as possible be secured on all sides, and that the parts be waxed and held firmly in place with a strong ligature until a union is effected. These details can only be carried out by giving very close attention to the work.

KNIFE FOR BUDDING THE MANGO.

The ordinary budding knife is not the best tool for the purpose of preparing buds and places for them. There are tools on the market for cutting and lifting sections of bark from stocks and scions which are more or less serviceable. A good device for this work can be easily made with two knife or razor blades, which should be firmly fixed in a piece of wood so that the edges will be apart from each other from an inch to an inch and a quarter. This instrument should be

used for cutting through the bark of the stock and marking that of the scion, or vice versa, as it will be found that the bud with a section of bark attached will not fit tightly into the place made for it by the cutter. In the case where the section of bark has to be cut by a knife the marks will indicate just where it is necessary to make the section large, so that a tight fit will be secured.

METHODS WHICH SHOW BEST RESULTS.

In the course of the Department experiments the writer discovered that by the use of a method of attaching buds described in the seventeenth century the finer varieties of the mango, with skillful handling, may be propagated quite as easily as the peach or other fruit tree.

APPLYING THE BUDS.

Two or three-year-old seedlings and moderate-sized trees may be used as stocks on which to bud approved varieties of the mango. The stems selected for the reception of the buds should be at least an inch in thickness. When of this diameter, both wood and bark are thoroughly ripe, and the union of the scion with the stock will be easily accomplished if the operation of inserting the buds is performed carefully. The method of budding which has been found to work most satisfactorily (Pl. II, fig. 1) consists in removing a rectangular piece of bark from the stock and inserting a piece similar in shape and a trifle larger in size, having a bud in the center, from a branch of a desirable variety. This method of budding was described by Robert Sharrock in his History of the Propagation and Improvement of Vegetables, published in 1672.

The only departure from Sharrock's method of budding as used in the case of the mango at the present time is that the bud, instead of being taken from new growth, must be selected from wood old enough to have lost its foliage. This means that the bud wood will sometimes be over 2 years old. The use of bark of this age and even older insures success in budding the mango, as it unites rapidly with bark of a similar age on seedling stocks or on branches of trees. To a certain extent success depends upon the precision with which the section of bark is removed from the stock and also from the variety to be propagated, as the more neatly the bud section is fitted into the space prepared for it the greater the probability of a successful union.

After the section of bark from the bud stick is nicely fitted in place, and before tying, a small quantity of grafting wax should be smeared over the parts where they come together and tied firmly in place with thick strands of raffia (Pl. II, fig. 1, C). This effectually prevents the admission of air to the spaces which, no matter how carefully the operation be performed, exist between stock and scion; it also serves

to prevent moisture from gaining access to the cut surfaces. The cut surfaces and all but the bud should then be covered with strips of cloth dipped in melted paraffin, wrapping being begun at the lower part, so that when finished water will not gain entrance to the wrapped section of bark. If that part of the stock where the bud is tied be exposed to the sun, it is always advisable to furnish shade, which is best supplied by strips of paper tied above the bud and extending down over it. Two weeks may be allowed to pass before an examination is made. The cloth wrappings may then be removed and the raffia should be loosened if there is danger of its cutting into the bark. When a sufficient time has elapsed to make certain that a union has taken place, part of the top of the stock should be removed in order to encourage the bud to start. This it will do with very little coaxing.

When sufficient growth has been made, all of the stock above the bud may be removed and the cut part coated with liquid grafting wax or tar to exclude moisture and prevent rotting.

WHEN TO BUD.

Budding may be performed at any time during the growing season, but with each plant there are certain periods when the operation will be found to be more successful than at other times. These periods are indicated by the growths or "flushes" being about half developed. At these times the sap appears to be more active than at others, as the bark peels from the wood more readily than when the growths are of firmer texture.

SELECTION OF BUDDING MATERIAL.

This part of the operation is of the utmost importance because success depends to a great extent upon the use of proper buds. Many growers who have tried to work buds of good varieties on seedling stocks are under the impression that the operation is an exceedingly difficult one, but this idea has arisen from the fact that the work has been prosecuted in a manner contrary to the demands of the structural details of the plant.

The mango is not the only tree which does not take kindly to young buds; in fact its propagation as carried on at the Department of Agriculture was suggested to the writer during some experiments in the propagation of the pecan by budding, as described in Bulletin No. 30 of the Bureau of Plant Industry. As has already been stated the 1-year-old wood of the mango is quite immature and comes far short of furnishing the best buds for propagation; therefore wood under this age should not be employed for budding if other material can be had.

A SECOND METHOD OF ATTACHING THE BUD.

Another method of attaching the bud varying slightly in the details from that given above has been practiced during the past season at Miami, Fla., with an encouraging degree of success. This method is shown in Plate II, fig. 2. The bud section differs from the rectangular-shaped piece of bark in that one end of it is pointed instead of being cut straight across, which makes it possible to push the bark of the scion down tight against the bark of the stock; the top part is then cut off square with the transverse cut in the bark of the stock, and is pressed firmly into position previous to tying and waxing in the usual way.

RAISING SEEDLING STOCKS.

The mango does not readily lend itself to propagation by cuttings on account of the green or immature condition of the shoots while the wood is still small in diameter. The writer has tried several batches of cuttings under varied conditions but always with poor success; they invariably callus well, but roots are slow to form, and when a cutting does produce a root it is usually a single fiber of so small and brittle a nature that the rooted cutting is difficult to transplant from the sand bed into pots or to the open ground.

It is necessary, therefore, to have recourse to seeds for the purpose of supplying plants to use as stocks for budding. The seeds should be sown very soon after being taken from the fruit, as they lose their vitality shortly after the fruit is ripe. Especially is this the case when the seeds are allowed to dry for a few days. The seed of the mango resembles that of the orange in that it often contains several embryos. Out of a batch of several hundred seeds sown in the Department greenhouses during the past season it was common to find instances where from two to five, and in a few cases no less than eleven, seedlings were produced from single seeds. Plate III shows eight plantlets all springing from one seed. This condition is not desirable, however, as in those cases where more than one or two seedlings sprout from the same seed they are usually of weak growth, and it is questionable whether they should be grown, especially when seeds are plentiful.

From the time the seeds are sown until the plumules appear above ground, the seed boxes or beds should be out of the reach of heavy rains, as the subterranean seed leaves are liable to rot when the soil is kept wet for any length of time.

When shallow garden flats are used in which to raise the seedlings the roots are under better control for future planting than if they were sprouted in beds or frames. An excellent medium in which to sprout the seeds is half-decayed leaves. A layer of leaves 1 inch thick is placed in the bottom of a flat; on this the seeds are deposited at

sufficient distances from each other to cover less than half the space. About an inch of half-decayed leaves is then placed over the seeds and pressed down firmly, the sowing being completed by slightly dampening the surface with a sprinkler.

If the surface layer of rotted leaves becomes dry at any time a gentle watering should be given, taking care not to soak the contents of the boxes. It is undoubtedly a safe plan to keep the contents of the boxes rather dry than otherwise during the sprouting period.

TRANSPLANTING YOUNG SEEDLINGS.

Germination is somewhat irregular; the first sprouts will appear in three or four weeks after sowing, but others will continue to appear for several weeks later. Nothing is gained, rather the reverse, by transplanting the seedlings when quite young; it is best to wait until the leaves of the first growth change from reddish brown to dark green. The seedlings can then be transplanted without wilting.

By the time the leaves of the seedlings reach a deep-green color a considerable quantity of roots will have formed which are capable of being removed from the flats without much injury, and if proper care is exercised in those cases where there are several plantlets from the same seed they may be disentangled successfully. Strong seedlings may go directly into 4-inch pots. Deep bamboo pots are much to be preferred when available, as owing to their greater depth there is less danger of the roots becoming matted while in the pots.

Immediately after the potting comes the crucial period in the life of the seedling, because there is danger of the leaves flagging, through the loss of a great deal of sap at a time when the roots are not in a condition to replace it. Therefore, until the roots gradually recover, it is advisable to keep the plants in a shaded house or frame and at the same time to supply a fairly humid atmosphere.

There is no necessity for keeping the young plants in pots for a long period. When the second or third growth has been made and hardened considerably, the new roots will have taken sufficient hold of the soil to insure the successful growth of the plant after it has been set out in its permanent position.

The soil to be used in potting should consist of fibrous loam, with sand and leaf mold in small quantities. In potting, the soil should not be rammed very firm for fear of bruising the roots, which are unusually tender. While the seedlings are in the pots watering will have to be performed as carefully as when in the seed boxes, to prevent souring of the soil and the consequent rotting of the roots.

IMPORTING MANGO SCIONS.

Scions of the improved varieties of the mango cost much less than plants to import from India and elsewhere in the Orient, but as a rule

they arrive in the United States in an unsatisfactory condition. With the purpose of ascertaining the most favorable methods of packing, Messrs. Lathrop and Fairchild, the agricultural explorers, recently sent several tin cases of scions of the Jaffna mango to the Department and the results obtained are of considerable importance for the guidance of intending importers. The batch of scions forwarded from Colombo, Ceylon, on April 6, 1902, and received at the Department May 5, consisted of four cylindrical tin tubes. One case contained bud sticks each less than three-quarters of an inch in diameter, the ends of all being covered with collodion. The bud sticks were afterwards dipped in clay mud, which formed a very tenacious covering. These scions were packed with a small amount of moist coir, and arrived in fairly good condition, although they were comparatively young growths. The same method of forwarding could probably be successfully applied to older wood, which has been proved to be of much greater service in budding operations.

Another case contained scions, half of which were wrapped in tin foil and the other half without wrapping. All were coated with collodion on the cut surfaces and packed in pure, fresh, moist sawdust. The contents of this box were almost dead when opened, those scions which were wrapped in tin foil showing more signs of life than the others. The scions in the third case were treated similarly to those in the second box, except that the packing material was moist coir instead of moist sawdust, plenty of air space being provided. These scions were in an advanced stage of decomposition. In the fourth lot the scions were wrapped in tin foil and packed in moist sawdust mixed with powdered charcoal. In this instance all were dead.

THE LOQUAT.

REGIONS WHERE THE LOQUAT MAY BE GROWN.

The loquat (*Eriobotrya japonica*) is a native of Japan and China. Its possibilities as a fruit tree have long been known in the South, where it is capable of being grown to perfection in several States. Young plants have proved hardy during mild winters at Washington, D. C., but when the temperature falls to zero and remains so for any length of time the plants are injured permanently. As the flowers of the loquat are produced during the autumn months, both flowers and fruit are likely to be injured by cold; for this reason there is little probability of the loquat being grown for fruiting purposes in regions where severe frosts are frequent.

However, there is a large tract of territory where the fruit may be successfully produced in this country. From Charleston south along the coast belt, in the Gulf States, and in California south of the thirty-eighth parallel it is quite hardy, and in some parts of New

Mexico and Arizona it will probably be found to thrive. In several States it ripens very large crops of fruit. Its period of blooming extends from September till frost, according to variety and location; the fruit ripens in spring.

In the more temperate regions many trees have been planted; most of them, however, are of seed origin, and it may confidently be said that were they of the finer varieties such as are cultivated in some parts of the Old World, the fruit would be more appreciated throughout the country. The trees at present in cultivation may be put to a very good use: they can be very easily worked with new varieties, as the loquat is one of the easiest subjects with which the propagator has to deal.

The agents of this Department have of late been assiduous in collecting new or little-known varieties, principally from the Mediterranean region, but also from China and Japan, and there are now in the Department greenhouses several kinds of great promise, from which a considerable quantity of bud wood may be distributed. Some of these varieties are said to be nearly seedless, a characteristic much to be desired, as the seeds are ordinarily quite large and occupy a considerable portion of the fruit.

RAISING SEEDLING STOCKS.

In a favorable climate the loquat bears heavy crops of fruit annually, and so gives an abundant supply of seed from which to raise plants to use as stocks for the reception of buds and grafts of the improved varieties. It will be found that when a tree sets a large quantity of fruit, a certain proportion will, within a short period, attain medium size and change color suddenly. These fruits, however, are almost tasteless, there being very little pulp in them; but the seeds are invariably good, and from the fact of ripening early they will, if sown as soon as gathered, produce larger plants by the end of the growing season than the seedlings raised from seeds which ripen later. As young loquat plants, budded or otherwise propagated, are not so difficult to transplant as are the great majority of evergreen trees, there is little necessity for pot cultivation, as the work of propagation can be performed in the open air without encountering any serious difficulty. The seeds should be sown an inch deep, about 6 inches apart, in rows distant from each other from 2 to 3 feet, to allow horse cultivation and to give an abundance of space for the operator to work when budding. After sowing, the ground should be covered with an inch or two of long stable litter, or any other material which will shelter the ground from the sun and at the same time be easily removed when the sprouts appear through the soil. At this period very careful cultivation is necessary, as it is imperative that the surface soil in the immediate vicinity of the young plants should be kept loose.

The seedlings will not make sufficient progress to permit budding operations during the first season, but by midsummer of the season following they will have attained sufficient size of stem for the buds to be attached with ease. They have been found after many trials to unite best by the common shield method. Plate IV, fig. 2, shows a 3-year-old stock budded two years.

Buds should be selected from well-ripened branches of small diameter, as these are easier to insert than buds taken from young succulent growths. The bark on 1 or 2-year-old seedlings is quite thick and easily bruised, and does not lift well; therefore, when buds from thick and succulent wood are used there is always difficulty in placing them under the bark of the stock. It will be found, moreover, that the buds in the axils of the fully developed leaves are exceedingly small and the bases of the petioles very large; consequently, buds of this nature are far from being the best with which to work. The loquat, as has already been hinted, is an exceedingly easy subject to propagate by budding or grafting. The buds, if properly inserted at a time when the bark lifts freely, will unite within two weeks, and a week or two later, if that part of the stock above the inserted bud is partly cut back, the buds will begin to grow very rapidly. The first indication of growth consists in one or two tiny leaves covered with light hairs. Shortly after these appear the top of the stock may be pruned to within an inch or two of the inserted bud, leaving only one or two mature leaves for a time.

Propagation by grafting is not commonly practiced. When comparatively large branches are headed back and scions inserted, the resulting unions are often unsatisfactory, being likely to be broken off by windstorms. A method of side grafting 6-months-old seedlings is shown in Plate IV, fig. 3. This method is very satisfactory and can be used best on seedlings grown in pots for shipping purposes.

THE FIG.

CUTTINGS.

The usual method of propagating the fig is by means of cuttings of the 1-year-old shoots. These cuttings are made in lengths of from 8 inches to several feet, according to the moisture in the soil. When the cuttings are not intended to be transplanted and are placed in the orchard to form trees, large-sized cuttings of 2-year-old wood are used, but when they are placed in nursery rows shorter lengths are usually selected, thus facilitating handling in transplanting or shipping. Where short cuttings will succeed, a length of from 8 to 12 inches will be found ample, the ends of the 1-year-old shoots giving most satisfaction, as the subsequent growth is, as a rule, straight and strong.

The best time to make the cuttings is in the fall when the season's growth is thoroughly ripe. Where the winters are not severe the cuttings may be put in the ground where they are to root. They are most easily cared for when placed in rows moderately close together, so that the young plants can be watered if necessary and cultivated with less labor than if put in the positions which the trees are intended to occupy permanently. In localities where the cuttings are likely to be injured by freezing weather they should be prepared in the fall and stored during the winter in moderately damp sand in a cellar. In early spring, or as soon as the soil is in a workable condition, trenches should be prepared for the reception of the cuttings, as they are likely to make roots very early.

In preparing the cuttings the usual custom is followed by making the lower cut just beneath a joint and where a terminal bud is not present the upper cut should be made about three-quarters of an inch above a joint. The soil must be deeply worked and the cutting inserted in the soil so that only the top bud is visible.

GRAFTING AND BUDDING.

Propagation by grafting and budding is sometimes resorted to, especially when trees prove to be unprofitable and it is desired to use them as stock plants on which to work good varieties. Another reason why budding and grafting may be practiced more than hitherto is that Smyrna and Capri figs may be worked on other varieties of old-established plants, and thus come into bearing much sooner than when raised from cuttings.

The successful colonization of the insect which pollinates the flowers of the Smyrna fig will result in greatly enlarging the fig-growing industry not only in California, but also in several other sections of the country, if the insects can be established and maintained through freezes.

Although the fig is not so easily propagated by the usual methods of grafting and budding as are most of the other kinds of fruit trees, yet there are several ways of accomplishing the desired result. In Bulletin No. 9 of the Division of Pomology of this Department Dr. Gustav Eisen describes a method of grafting the fig employed in California. This is a modification of the cleft graft, which is used mainly on branches of large diameter and is successful when skillfully done. It differs from ordinary cleft grafting in that the cuts for the reception of the scions do not point to or cross the pith, but are directed to one side. The operation must be performed when the trees are in a dormant condition.

An exceedingly simple method of grafting which may be used by a person having little experience in this line of work has been successfully practiced at the Department of Agriculture for some time.

This method consists of preparing the stock for the reception of the scion as in shield budding. This is done by making a transverse cut through the bark three-quarters of an inch in length. From the middle of this incision another cut is made toward the main stem or root for fully an inch. The bark is then prized up as seen in Plate V, D. Instead of inserting a single shield bud, a small twig having one terminal and one or two lateral buds is used (Pl. V, A, B, C). The scion is prepared as follows: A long scarf is made at one side through the pith and a thin piece of the bark on the reverse side is removed. With the long cut facing the stock the scion is pushed deeply into the place prepared for it (Pl. V, E) and is tied firmly with raffia. The corners of the bark of the stock are brought close to its own stem and bound firmly in that position (Pl. V, F). Melted grafting wax should then be put on, or narrow strips of waxed cloth may be applied instead, to exclude air and moisture. If possible, the scions should be selected from branches not over one-half an inch in diameter when they can be found of sufficient firmness of that thickness. Small lateral shoots having a terminal bud and only an inch or two in length and quite thin will unite by this method very easily. It is not necessary for the scions to be dormant, but they should be fully matured and the leaves cut off to about one-half inch from the buds. The bark slips readily from the time growth begins in spring, so that the operation may be performed at any period during late spring and summer.

In the course of about two weeks after the operation is performed, if the scions remain fresh, the probabilities are that a union will have been effected. Part of the top of the stock may then be removed to induce the scion to start growth, and when it has made some headway the top of the stock may be cut off near the scion.

Seedlings are well suited to this method of propagation for use as stocks, as the bark near the ground line is quite thick and lends itself readily to scion budding. The seedlings should be at least 2 years old. At this age that part of the stem near the collar is much greater in diameter than will be found a few inches above, thus allowing a good-sized scion to be inserted.

TEA.

NECESSITY FOR VEGETATIVE PROPAGATION.

Dr. Charles U. Shepard, of Summerville, S. C., whose successful tea-growing experiments entitle him to rank as the highest authority on this subject in America, has concluded that future plantations of some of the varieties now grown and which have been raised from seed must be propagated vegetatively because of the important fact that some of the individual plants in a batch of seedlings show great superiority over others in several of their characteristics, as for

instance, in leaf production and in the quality of the product. In other words, seeds can not be relied upon to reproduce the exact characters of the parent plant. Dr. Shepard also finds that some forms which produce superior teas have very poor roots, thus necessitating grafting upon stronger-rooting varieties.

The propagation of the desirable varieties of the tea plant may be secured in several ways according to the object to be attained. For instance, grafting should be the method chosen in cases where a desirable variety has a poor root system; because by taking young plants of varieties known to form good roots and using them as stocks the poor-rooting kinds may be united to them by means of the veneer method of grafting. Again, the stock of desirable plants of any particular variety having good root systems can be increased by layering, if the plants have previously been prepared by pruning so as to provide suitable wood for the purpose.

The quickest and least troublesome method of propagation is by cuttings of the newly ripened shoots (Pl. VII, figs. 1 and 2). None of the above-named operations is difficult, but to perform any of them successfully requires constant care and attention to the details while the scions are uniting with the stocks or when the branches and cuttings are forming roots. Sometimes, in layering operations, the weather supplies conditions which enable the branches to root without further care on the part of the operator; but not so with grafts and cuttings, as these operations must be carried on under conditions which require continual care during the period required for uniting or for rooting. Any neglect at this time is certain to result disastrously.

VENEER GRAFTING.

Seedling stocks may be grown in 4 or 5-inch pots for the reception of scions by the veneer method of grafting. To have the plants in perfect condition for working, it is necessary that they be grown from the seedling stage without a check, as the healthier the plant the better the chance of a successful union. Another important matter in this connection is that the stock plants should not be allowed to form matted roots in small pots; therefore, it will be found better to lift them from the nursery and put them in pots previous to the operation; or they may be grown and grafted while in garden flats. If this last-named method is chosen the plants should be situated far enough apart in the flats to be easily handled. If the grafting is performed while the stocks are in active growth, the union will take place more quickly than when the plants are in a dormant condition. The operation should be performed in the early part of spring. Plate VI, A, shows how the incision in the stem should be prepared. This should be made with a sharp knife and the cut at the deepest part should not be

more than one-third of the diameter of the stem. The scion (Pl. VI, B) must be shaped at the base so that it will fit neatly into the place prepared for it on the stock. It should then be tied as seen in Plate VI, C, and afterwards a small quantity of sphagnum moss should be tied over the part where the stock and scion come together, as shown in Plate VI, D.

Immediately after the operation is performed as above described, the plants should be placed in a close, shaded propagating frame and kept there until the union is effected; this will take place in a few weeks. The temperature of the frame should be kept uniformly at from 60° to 65° F. If a layer of moss be put under the pots and the contents of the frame syringed occasionally a favorably humid atmosphere will result. Where greenhouse accommodations are not available for the propagating frame a hotbed may be built out of doors in a location where the sun will not have much effect in raising the temperature. From 6 to 9 inches of stable litter and leaves will provide ample heat during the spring. When it is found that the scions have made connection with the stocks, air should gradually be admitted to the frames. Shortly after this the tops of the stocks may be cut off close to the scions. Planting out may be deferred till the scions have made their first growth.

HERBACEOUS GRAFTING.

Another method which the writer has tried successfully is herbaceous grafting. This consists in removing the top from a seedling when a few weeks old, making a clean, straight cut through the stem above a bract or a leaf, much in the same way that coffee seedlings are treated for grafting, but with this difference: In the case of the coffee the very large cotyledons persist for many months after germination and, being well above ground, they perform the functions of true leaves, so that when the plumule is severed grafting is performed with ease and the seedling receives only a very slight check. But with tea the cotyledons are underground, and although they also persist for a considerable time the plumule can not be removed with the same degree of safety as with coffee. Therefore it is best to remove the top above a bract or leaf. A cut is then made through the stem, as for cleft grafting, and the base of the scion is cut to a wedge shape, so as to fit nicely into the stock. It is kept in place by wrapping with thin strands of raffia. It will be found easiest to perform this operation when the seedlings are in flats, as then they occupy less room than when in small pots. It is necessary for all grafted plants to be kept in a close and shaded frame while the scions are uniting with the stocks.

PROPAGATING HOUSE.

In preparing for cuttings, a cool propagating house is the first requisite. It should be a lean-to structure and so built that the slope

will face the north. The interior may be about 8 feet wide. This space will be ample for two benches, each 2 feet 9 inches wide, one on each side of a central path, 2 feet 6 inches wide. The heating apparatus should be sufficient to keep the sand at a temperature of 60° F., and the temperature of the house should not fall below 50° F. At all times a humid atmosphere should be maintained. During bright sunshine the glass should be shaded. One way to accomplish this is by lengths of cloth fixed on rollers. There is, however, always danger of neglecting to lower the cloth at the proper time, so that the safer plan would be to put on a permanent shade by painting the glass with white lead and turpentine. The benches should be constructed at a height of about 3 feet from the floor, and the uprights so made that the pipes may be boxed in, leaving a small door, provided with leather hinges, at intervals of 8 or 10 feet to supply the necessary heat to the house during extra cold weather. The bottom of the bench should be of wood, 2-inch planks being the preferable size, one-quarter inch spaces being left between the planks for drainage. Four inches of clean sand will be ample. Previous to putting in the cuttings beat the sand firmly with a piece of 4 by 4 inch scantling. The beds are then ready for the cuttings.

CUTTINGS.

The cuttings of the tea plant take a long time to root, and consequently it has been found that the most propitious season for rooting is during the winter months, the cuttings being put in the sand any time during the month of November.

The best wood to use for the cuttings is a moderate-sized branch of the current season's growth taken from a plant the leaves of which have not been picked over within the previous six months. As many branches should be cut at one time as will make about 500 cuttings, the leaves being dampened with a sprinkler as soon as they are brought indoors and the cuttings made before the leaves have an opportunity to dry out. They may be made into lengths of from 4 to 5 inches (Pl. VII, figs. 1 and 2), as cuttings longer than that are not so certain to root. A medium-sized shoot will make several cuttings. The terminal part of the shoot may be used if the wood is firm or well ripened. At least two leaves should be left on each cutting, and if the leaves are quite close together several may be left. The reason for leaving only a few leaves is that the nearer they are to the surface of the sand the better the chance of the cutting to root, as the moisture condenses on the under surface of the leaves, thereby keeping the cutting in a crisp and fresh condition until the roots are formed. Plate VII, fig. 2, shows two cuttings ready to be put in the sand. In putting in the cuttings the propagator will usually find it most convenient to work from left to right. The necessary tools are a dibble, a flat piece of

board 2 inches in width and as long as the bed is wide, and the sand beater already mentioned. The piece of board should be placed 2 inches from the end of the bed and a line drawn with the dibble close to the board across the bed; this will mark the position which the first row of cuttings is to occupy. Each cutting should be put in with the aid of the dibble, first making a deep hole with the instrument; then the base of the cutting should be put into it as far as it will go, allowing the bottom leaf or leaves to rest on the sand and pressing the sharp end of the dibble once or twice down into the sand close to the stem of the cutting, firming it in its place. By this operation the cutting should occupy a space of about 2 inches each way. When a row is put in the sand the board should be placed as close to it as it will go and two or three sharp taps given it with the sand beater, which will still further help to firm the cuttings; then the work should proceed as before. When a batch of cuttings is put in, enough water should be given through a large sprinkler to settle the sand around the bases of the cuttings. After the beds are filled the subsequent treatment should consist of frequent slight syringings in preference to heavy watering at any one time. The atmosphere should never be allowed to become dry. During periodical spells of warm weather the heat should be turned off and a little air given, but not enough to cause drafts in the house.

MANILA HEMP.

IMPORTANCE OF INTRODUCTION INTO THE UNITED STATES.

The plant which yields the fiber known as Manila hemp is a species of banana (*Musa textilis*). It is indigenous to the Philippine group and other Pacific islands south to the Moluccas. The hemp-growing industry is conducted almost exclusively in the Philippines, as in some parts of the islands the climate is perfectly adapted to the growth of the plant, its principal requirements being a moderately high temperature and a well-drained, moist soil. The Manila hemp grows to a height of 20 feet, and requires at least 3 years to reach the stage which is best for the production of the fiber.

It may be mentioned here that what is commonly called the trunk of the banana plant is not really a trunk, but merely a continuation of the leaf stalks, the outer ones folding over or clasping the inner ones in such a way that a trunk-like formation is the result. The fiber is found in this trunk-like body and is harvested shortly after the plant comes into flower.

In the recently issued Pronouncing Gazetteer and Geographical Dictionary of the Philippine Islands it is stated that nearly 100,000 long tons of Manila hemp are annually exported from the Philippines, chiefly to the United States and England. The first grade of fiber from 1885 to 1894 ranged in price per kilogram (2,204 pounds),

between $6 and $17.12. The inferior grades were 25 to 40 per cent lower in the Manila market. The Gazetteer states that under existing conditions, abaca Manila hemp plantations in the Philippines with careful management yield an annual return of 30 per cent on the investment, which indicates what may be expected from successful hemp plantations in the near-by tropical possessions of the United States.

The introduction of the Manila hemp plant into the United States has been attempted several times, but without success until recently, when a supply of seed was received at the Department of Agriculture from the insular bureau of agriculture of the Philippines.

RAISING PLANTS FROM SEEDS.

The plant is exceedingly easy to increase by dividing the underground stems, but in order to get a supply of plants for this purpose propagation by seeds has, of course, to be resorted to.

As the seeds received from the Philippines have been successfully germinated, an account of the means by which this result was secured may be of value to those who contemplate raising a stock in this way. The seeds were gathered in the Islands as soon as ripe, mixed with finely powdered charcoal, and shipped to Washington in small cylindrical tin tubes. A period of about forty days thus occurred between the time of gathering and the time of sowing. As it has been thought that the seeds lose their germinative power in less time than this, owing to their failure heretofore to germinate in this country, some of the seeds were kept and sown at intervals of from one to six weeks. The percentage of germination was high in every case, and, although it has not been ascertained just how long the seeds will retain their vitality after ripening, it would seem that the methods formerly used to germinate them were faulty.

These seeds were sown in garden flats filled to within an inch of the surface with clear, large-grained river sand, upon which the seeds were scattered, pressed down firmly, and covered with one-half inch of sand. A sheet of glass was placed over the box and the sand kept at a temperature varying from 75° to 80° F., the lower temperature occurring during the night. Only one slight watering was given before germination. In fourteen days after the seed was sown the plumules gradually made their appearance, and in three weeks more the plantlets were large enough to go into small pots (Pl. VIII). To give them favorable greenhouse treatment in this latitude, the glass during autumn should be without shade and the temperature of the house 60° F. by night and 20° higher during the day.

In the island of Porto Rico, where it is intended to start plantations, the seeds may be sprouted with the aid of a frame and sash, but it is evident that a slight bottom heat should be maintained, especially

during the sprouting period. This will be most easily supplied by a layer of stable manure, mixed with leaves, to the depth of a few inches. Over this some ashes should be placed, packing the mass very firm. The bed should then be finished off with sand to a depth of 2 inches. The seedlings will make considerable growth in pure sand, and it would perhaps be advisable to transfer them previous to permanent planting, when they attain a height of from 2 to 4 inches, to nursery beds of well-prepared soil. As an alternative, the seedlings, after being exposed to the maximum amount of light and air while in the seed bed for a period of two or three weeks, may be planted out in their permanent quarters during cloudy or even wet weather; that is, if the nature of the soil will permit it. Well-drained soils with an abundance of humus in their composition will not offer any great obstacle to planting even in wet weather, and the plants will certainly benefit by this treatment.

CULTIVATION IN THE PHILIPPINE ISLANDS.

In a paper entitled "La culture de l'abaca aux Philippines," by De Berard, published in L'Agriculture Pratique des Pays Chauds, 1901, an account is given of the propagation of the Manila hemp by seeds and its cultivation in the Philippines. The author names the following varieties grown in the isle of Luzon: Moro Blanco, Moro Negro, Moro Colarado, Turncan ou Mosqueado, Tagacan Blanco, Tagacan Colarado, Bagacayan, and Samina.

With respect to the climate, it is stated that in order to reach the maximum production there must be considerable humidity. The limit of altitude for cultivation is given at from 300 to 400 yards. The plants are said to be partly grown in the shade of trees having open branches and light foliage, but not near enough to let the roots interfere with those of the bananas. The fiber from plants grown in dense shade is finer and longer, but less strong, than that from plants grown without shade; however, the fiber which combines fineness, length, and strength commands the highest price. The land described as best suited for the plant consists of moist but well-drained volcanic soil, mixed with vegetable humus. It is stated that the method by which the hemp plant is propagated in Albay and in South Luzon, where the best fiber is produced, is by seeds and also by division of the underground stems. The last method is generally preferred by cultivators, as it entails less work and produces better results. The collecting of seeds is carried on in a careless way by the cultivators of the many small plantations, resulting in great irregularity in the quality of the product, owing to the mixing of strains or varieties in the same plantation. In raising the seedlings it is said that previous to sowing, the seeds are soaked in warm water for several hours, washed, and dried in

the shade, then sown two together in prepared holes from 5 to 8 inches apart, and covered with fine soil to a depth of three-fourths of an inch. The beds are then covered with a light layer of straw, which is set on fire. This last operation has for its object the hastening of germination. The beds are watered very lightly for several days, always before sunrise. Only enough water is given to make the soil moist on the surface. If the nursery is exposed to the full sun, shade is provided, but only during the warmest part of the day. After fourteen or fifteen days the seeds begin to germinate, and when the seedlings reach a height of from 2½ to 3 feet they are transplanted to well-prepared soil at a distance of from one-half to 2 yards apart and watered only until established.

PLATES.

DESCRIPTION OF PLATES.

PLATE I. Fig. 1.—Method of inarching branch of improved variety of mango, used at the present time in India. Two seedling stocks are planted so that their stems grow side by side; a single branch is then inarched to the two stocks. When the union is complete the branch is severed from the parent tree. Fig. 2.—Saddle method of inarching mango on seedling stocks, used in India. Although an unsatisfactory method of propagation this gives a better union than that shown in fig. 1. Fig. 3.—Mangoes propagated in India, showing their condition upon arrival in the United States.

PLATE II. Fig. 1.—Rectangular patch method of budding the mango. When stocks of at least 1 inch in diameter are used this method has given the best results in the greenhouses of the Department of Agriculture. Fig. 2.—A method of budding used with considerable success in Florida. Fig. 3.—Budded mango seedling, showing first and second growths from an inserted bud. In order to induce the bud to start the stock is headed back about 1 foot above the bud. When two growths have been made, the stock is cut back close to the bud.

PLATE III. Germination of mango, showing eight plantlets springing from one seed. One-half natural size. The stage of development shown in the illustration occurs about six weeks after planting the seeds.

PLATE IV. Fig. 1.—Crown grafting the loquat on tall stocks, showing a bad union. Fig. 2.—A 3-year-old loquat stock, budded two years, showing a good union. Fig. 3.—Side grafting the loquat, 6-months-old seedlings being used as stocks. A, scion inserted; B, scion inserted, tied, and waxed; C, scion united and growing and stock cut back.

PLATE V. Scion budding the fig. A, B, C, scion prepared for inserting; D, bark raised ready for the reception of the scion; E, base of the scion inserted under the bark of the stock; F, scion inserted and tied.

PLATE VI. Veneer grafting the tea on 1-year-old seeding stocks. B, scion ready for placing in position in incision on stock shown at A; C, scion inserted and tied with raffia; D, small quantity of damp sphagnum moss tied around the stock and scion.

PLATE VII. The propagation of the tea by cuttings of the ripened wood. Fig. 1.—Cuttings ready to be placed in sand. Fig. 2.—Rooted tea cuttings ready to be placed in soil.

PLATE VIII. Manila hemp. Six-weeks-old seedlings showing seeds still attached to the plants. Natural size.

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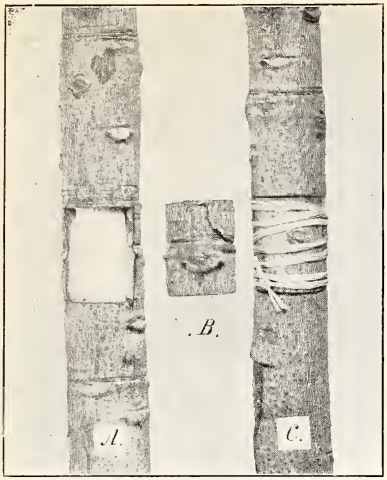


FIG. 1.—RECTANGULAR PATCH METHOD OF BUDDING THE MANGO.

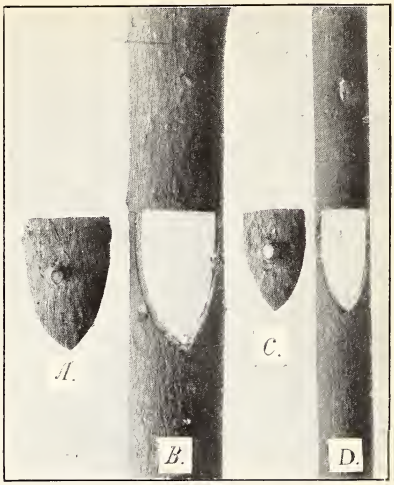


FIG. 2.—METHOD OF BUDDING THE MANGO USED IN FLORIDA.

FIG. 3.—BUDDED MANGO SEEDLING, SHOWING FIRST AND SECOND GROWTHS FROM INSERTED BUD.

GERMINATION OF MANGO, SHOWING EIGHT PLANTLETS SPRINGING FROM ONE SEED.

FIG. 1.—CROWN GRAFTING THE LOQUAT, SHOWING A BAD UNION.

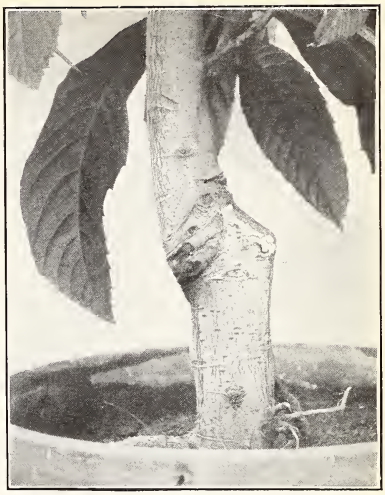
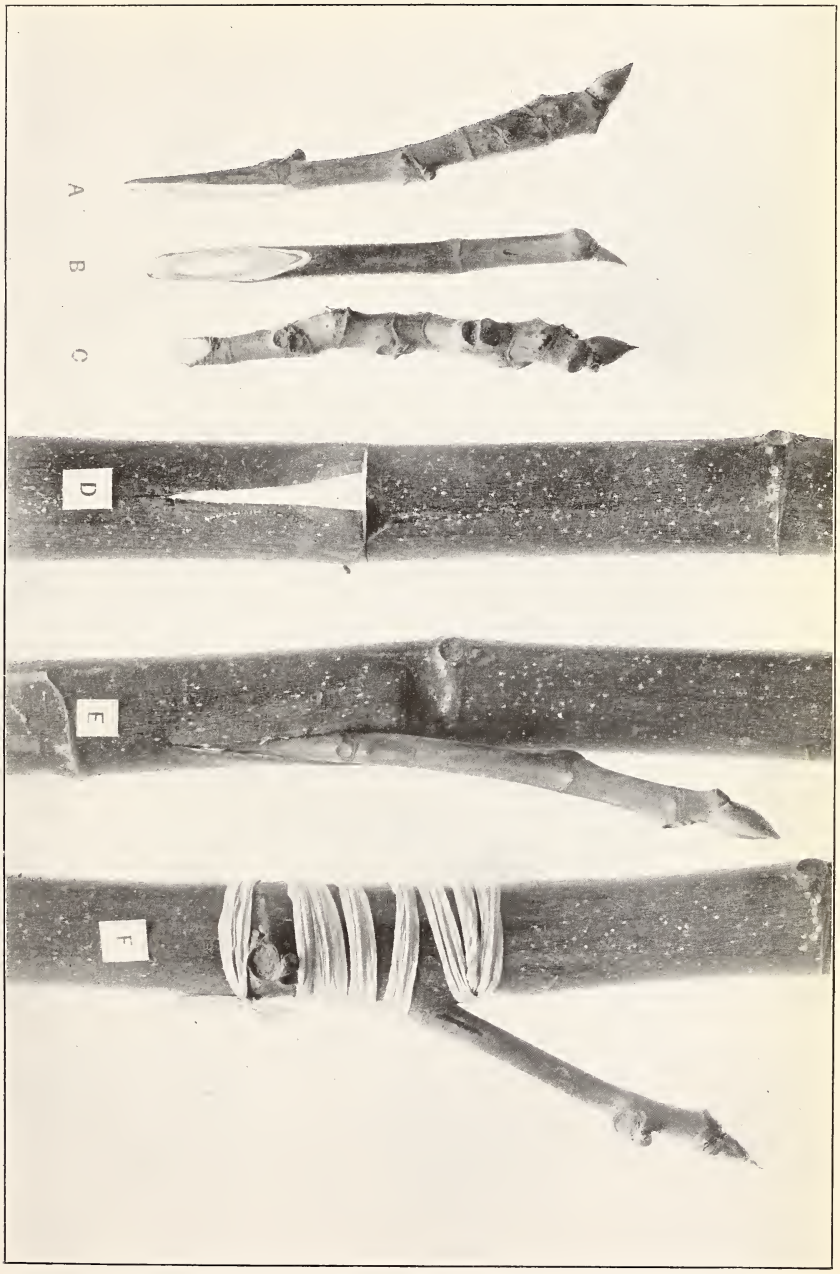


FIG. 2.—A 3-YEAR-OLD LOQUAT STOCK, BUDDED TWO YEARS.

FIG. 3.—SIDE GRAFTING THE LOQUAT ON 6-MONTHS-OLD SEEDLINGS.

A, Scion inserted; B, scion inserted, tied, and waxed; C, scion united and growing and stock cut back.



SCION BUDDING THE FIG.

VENEER GRAFTING THE TEA PLANT.

Bul. 46, Bureau of Plant Industry, U. S. Dept. of Agriculture.

FIG. 1.—TEA CUTTINGS READY TO BE PLACED IN SAND.

FIG. 2.—TEA CUTTINGS READY TO BE PLACED IN SOIL.

THE PROPAGATION OF TEA BY CUTTINGS.

MANILA HEMP. SIX-WEEKS-OLD SEEDLINGS. (NATURAL SIZE.)